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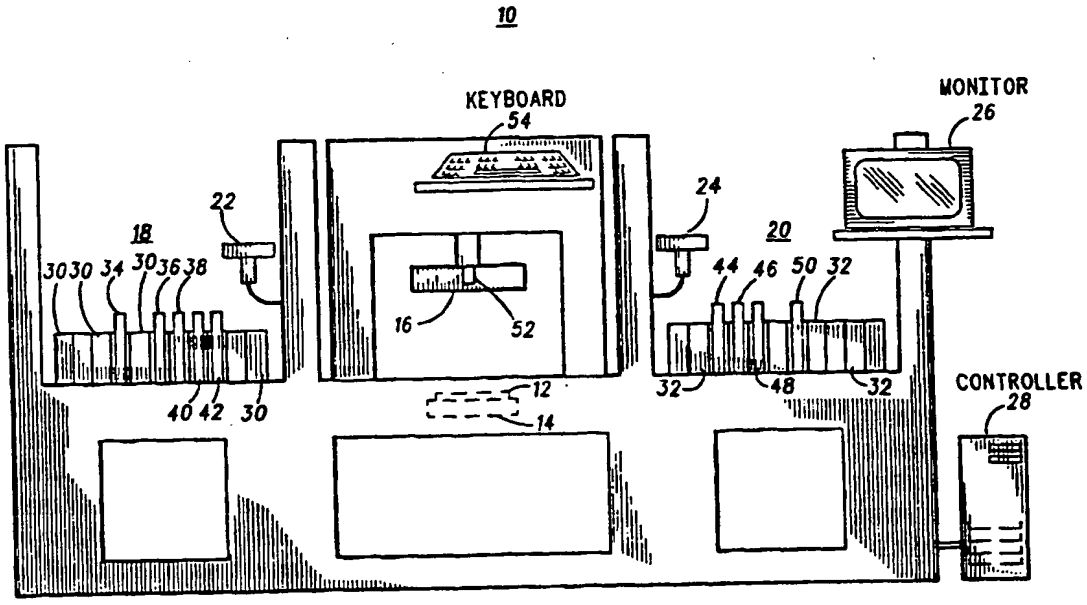

(57) Abstract

An apparatus (10) automatically assembles a plurality of electrical components stored in a like plurality of component feeders (34, 36, 38, 40, 42, 44, 46, 48, 50) into a printed circuit board (12). Each component feeder includes a component identifying bar code (92) and each component supply station includes a visual indicator (64). An optical bar code reader (22) reads each of the bar codes one at a tim . A controller (28) correlates each of the bar codes with a corresponding one of the component supply stations. A detector (66) associated with each component supply station detects the presence of a component feeder in its associated component supply station.

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Closed L p Comp nent F eder Loading Verification System

Background of the Invention

The present invention generally relates to an apparatus which automatically assembles a plurality of components into a finished product. The present invention more particularly relates to such an apparatus which includes a plurality of component feeders wherein each component feeder stores a plurality of a given one of th components and is to be received in a given one of a plurality of component supply stations. The apparatus includes a system which provides assistance to an operator in loading each component feeder into its proper component supply station and verification of such proper loading.

Apparatuses for automatically assembling a plurality of components into a finished product are well known in the art. One such apparatus, for example, is a pick and placement machine used in the printed circuit board industry for inserting a plurality of electrical components into a printed circuit board under assembly. Such machines, in assembling a printed circuit board, sequentially align the printed circuit board with a plurality of component supply stations one at a time under computer control. Each component supply station is provided with a component feeder which stores a plurality of a given one of the electrical components. When a component supply station is brought into alignment with the printed circuit board, either due to the movement of the printed circuit board to the component supply station or the movement of the component supply station to the printed circuit board, a component is removed from the feeder with a vacuum pick-up tube and conveyed to an insertion mechanism where it is inserted into a predetermined location of the printed circuit board. When all of the components hav been inserted into the printed circuit board, the component leads are then soldered to the printed

circuit board conductive pattern in a single soldering process.

The component supply stations are generally arranged side by side on a device table. The supply stations are closely adjacent each other and include alignment means for properly aligning each component feeder in its corresponding component supply station. If a component feeder is loaded into an improper supply station, the component stored therein will be inserted into an improper location of the printed circuit board. Hence, it is vitally important that each component feeder be loaded into its proper corresponding component supply station.

At least two systems are known in the prior art for verifying that the correct component feeders have b en loaded into the proper component supply stations. One such system uses a unique pinout configuration for each component feeder. The pinouts, after all of the component feeders have been loaded, are interrogated by a verification system to determine if all of the component feeders have been properly loaded. While this system serves the intended purpose, it is relatively complex and only provides verification after all of the component feeders have been loaded. Hence, the system is not interactive with the operator of the apparatus during th loading of the component feeders.

In another system, a unique optical bar code is provided for each component feeder. After all component feeders are loaded, the optical bar codes are read and transmitted with an RF transmitter to an RF receiver associated with a verification system. The verification system then verifies if all of the component feeders have been properly loaded. Again, this system is also relatively complex and is not interactive with the operator.

In another system, the optical bar code of each component feeder is read prior to loading it into its component supply station. However, sinc the supply

stations are closely positioned, this does not insure that the feeder will be loaded into its correct supply station.

As can be seen from the foregoing, neither of these systems provides an uncomplicated solution to the problem of assuring that all of the component feeders are properly loaded. Further, neither system is interactive with an operator to assure that each component feeder is properly loaded at the time of being loaded. Lastly, neither system assists an operator in loading a new component feeder when component replenishment is required for one of the component feeders.

Summary of the Invention

The present invention therefore provides an apparatus for automatically assembling a plurality of components into a finished product wherein the apparatus sequentially aligns a product under assembly with a plurality of work stations and wherein each work station is dedicated to provide a given component for assembly in the product under assembly. The apparatus includes a plurality of component storage means, each component storage means for storing a plurality of a given one of the components and including a component identifier identifying the given one of the components stored therein. The apparatus further includes receiving means at each of the work stations for receiving one of the component storage means, each receiving means including visual indicator means for providing a visual indication and reading means for reading each of the component identifiers, one at a time. The apparatus further includes correlating means for correlating each of the component identifiers with a corresponding one of the receiving means. The correlating means is coupled to the reading means and to each of the visual indicator means and is responsive to the component identifiers for causing, for each component identifier read by the reading means, a corresponding one of the visual indicator means to provide the visual indication to assist an operator in loading each

component storage means into its corresponding receiving means.

The apparatus may further include detecting means for detecting the presence of one of the component storage means in its receiving means, and wherein the correlating means incudes verification means for verifying, after each component storage means is loaded into one of the receiving means, whether the loaded component storage means has been received by its corresponding receiving means.

The present invention further provides an apparatus for automatically assembling a plurality of electrical components into a printed circuit board. The apparatus sequentially aligns a printed circuit board under assembly with a plurality of component supply stations wherein each component supply station is dedicated to provide a given component for assembly in the printed circuit board under assembly. The apparatus includes a plurality of component feeders, each component feeder storing a plurality of a given one of the components and including a component identifier for identifying the given one of the components stored therein and receiving means at each one of the component supply stations for receiving one of the component feeders wherein each component supply station includes visual indicator means for providing a visual indication. The apparatus further includes reading means for reading each of the component identifiers one at a time and correlating means for correlating each of the component identifiers with a corresponding one of the component supply stations. The correlating means is coupled to the reading means and to each of the visual indicator means and is responsive to the component identifiers for causing, for each component identifier read by the reading means, the corresponding one of the visual indicator means to provide the visual indication to assist an operator in loading each component feeder into its corresponding component supply station.

The present invention further provides a verification system for use in an apparatus which automatically assembles a plurality of components into a finished product, wherein the apparatus sequentially obtains a component for assembly from each of a plurality f component supply stations, and wherein each of the component supply stations is provided with a component feeder, each component feeder storing a plurality of a given one of the components. The verification system provides assistance to an operator in loading each component feeder into its corresponding component supply station and includes component identifier means associated with each component feeder for identifying the given one of the components stored therein, visual indicator means associated with each component supply station for providing a visual indication, and reading means for reading each of the component identifier means one at a time. The verification system further includes correlating means for correlating each component identifier means with a corresponding one of the component supply stations. The correlating means is coupled to the reading means and to each of the visual indicator means and is responsive to the component identifier means for causing, for each component identifier means read by the reading means, a corresponding one of the visual indicator means to provide the visual indication to assist an operator in loading each component feeder into its corresponding component supply station.

The present invention further provides an apparatus for automatically assembling a plurality of components into a finished product wherein the apparatus sequentially aligns a product under assembly with a plurality of work stations and wherein each work station is dedicated to provide a given component for assembly in the product under assembly. The apparatus includes a plurality of component storage means, each component storage means for storing a plurality of a given one of the components, receiving means at each one of the work stations for r ceiving ne of the

component storage means, and control means for establishing a correspondence between each component storage means and corresponding ones of the receiving means. The apparatus further includes detecting means associated with each receiving means for detecting the presence of one of the component storage means in its associated receiving means, and correlating means responsive to the control means and the detecting means for verifying, after each component storage means is loaded into one of the receiving means, whether the loaded component storage means has been received by its corresponding receiving means.

The present invention still further provides an apparatus for automatically assembling a plurality of components into a finished product, wherein the apparatus sequentially aligns a product under assembly with a plurality of work stations, and wherein each work station is dedicated to provide a given component for assembly in the product under assembly. The apparatus includes a plurality of component storage means, each component storage means for storing a plurality of a given one of the components and including a component identifier identifying the given one of the components stored therein, receiving means at each one of the work stations for receiving one of the component storage means, and reading means for reading each of the component identifiers one at a time prior to loading each of the component storage means into one of th receiving means. The apparatus further includes correlating means for correlating each of the component identifiers with a corresponding one of the receiving means. The correlating means are coupled to the reading means and each of the receiving means includes detecting means for detecting the presence of any of the component storage means in the receiving means. The correlating means includes verification means for verifying, after each component storage means is loaded into on of the receiving means, whether the loaded component storage means has been received by its corresponding receiving means.

This feature uses only one bar code reader and insures that the component storage means (component fe der) whose component identifier has not been read has then been loaded into the proper corresponding receiving means (supply station). This is achieved by using presence detectors, such as Hall effect sensors or microswitches, to detect when a supply station is loaded with a component feeder. This feature allows easy retooling of existing bar code reader systems to avoid loading a component feeder into the wrong supply station. It also does not require a plurality of different bar code readers and it does not requir loading all component feeders prior to testing for correct loading.

Brief Description of the Drawings

Fig. 1 is a plan view of an apparatus which automatically assembles a plurality of components to provide a finished product and which embodies the verification system of the present invention.

Fig. 2 is a perspective view of a device table and a component feeder of the apparatus of Fig. 1.

Fig. 3 is a side view of the component feeder and a top portion of the device table in spaced apart and aligned relation to illustrate certain aspects of the present invention.

Fig. 4 is a schematic block diagram of the verification system of the present invention configured in accordance with a preferred embodiment of the present invention.

Fig. 5 is a flow diagram illustrating the manner in which the verification system of the present invention may be implemented in accordance with a preferred embodiment.

Fig. 6 is a flow diagram illustrating the manner in which the verification system of the present invention may be implemented when th operation of the apparatus is disturbed.

Description of the Pref rred Embodiment

Referring now to Fig. 1, it is a rear plan view of an apparatus 10 embodying a verification system configured in accordance with a preferred embodiment of the present invention. The apparatus 10, aside from the verification system to be described in greater detail hereinafter, is a pick and placement machine for inserting a plurality of electrical components one at a time in sequence into a printed circuit board 12 disposed on a servo-driven table 14. The apparatus 10 is more preferably a pick and place machine distributed by Fuji America Corp. of Lincolnshire, Illinois, under Model No. CP-3 or Model No. CP-4.

The apparatus 10 generally includes a pick and place section 16, a first device table 18, a second device table 20, and a verification system embodying the present invention. Those elements of the verification system shown in Fig. 1 include bar code readers 22 and 24, a monitor 26, and a controller 28.

The device tables 18 and 20 include a plurality of component supply or work stations 30 and 32 respectively. Each of the component supply stations 30 and 32 is adapted to receive a component feeder and, as depicted in Fig. 1, selected ones of component supply stations 30 are provided with component feeders 34, 36, 38, 40, and 42 and selected ones of component supply stations 32 are provided with component feeders 44, 46, 48, and 50. As is well known in the art, each of the component feeders stores a plurality of a given one of the electrical components to be inserted into the printed circuit board 12.

The pick and place section 16, also as well known in the art, includes a pick-up tube 52 which, under a vacuum, picks the components stored in the component feeders and conveys the components to an insertion mechanism (not shown) which then, under computer control, inserts th components into the printed circuit board 12 at predetermined locations. More specifically, each printed circuit board to be assembled is associated with a

respective computer program which is selected on a keyboard 54. The computer program controls the sequence of the component insertions and the movement of the servo-driven table 14 so that each electrical component is inserted in the proper sequence and in the proper location of the printed circuit board under assembly.

The device tables 18 and 20 are moveable in a linear direction from a home position as illustrated in Fig. 1 to the pick and place section 16. Under the computer control, the device tables are moved so that each of the component supply or work stations 30 and 32 are sequentially brought into alignment with the pick-up tube 52 and the circuit board 12 in the proper sequence. Since each component supply station equipped with a component feeder is dedicated to provide a given one of the components to be inserted into the printed circuit board 12, it is vitally important that each of the component feeders be received by its corresponding component supply station. If a component feeder is loaded into an incorrect component supply station, the components which it supplies will be inserted into the wrong locations of the printed circuit boards. The verification system of the present invention insures that all of the component feeders are loaded into the proper corresponding component supply stations.

As will be seen hereinafter, each of the component feeders is provided with an associated component identifier which identifies the given one of the electrical components stored therein. Preferably, the component identifier is in the form of an optical bar code.

After the computer program associated with the printed circuit board to be assembled is selected on the keyboard 54, the controller 28 stores in internal memory the proper correlation between each of the component supply stations to receive a component feeder and the corresponding component identifiers of the component feeders required by the computer program for assembling the print d circuit board. Each of th component supply stations is associated

with a visual indicator such as, for example, a light emitting diode. After the controller completes its correlation, it illuminates all of light emitting diodes associated with the component supply stations which are to receive a component feeder. An operator then scans each of the component feeder component identifying bar codes with one of the bar code readers 22 or 24 one at a time. For each bar code which is scanned, the controller 28 causes the visual indicator associated with the corresponding component supply station to provide a discontinuous or flashing visual indication to indicate to the operator which one of the component supply stations is to receive the component feeder having the bar code which has just been scanned. The operator then loads the component feeder into the component supply station having the flashing indicator. If the operator should happen to load the component feeder into an incorrect component supply station, the controller 28 will then provide an error indication such as a visible error indication on the monitor 26. If such an error indication results, the operator then once again scans the bar code on the component feeder and repeats the loading sequence until the component feeder is loaded into its proper corresponding component supply station.

After all of the component feeders required by the computer program for assembling the given printed circuit board have been loaded, the controller 28 then provides a final verification that all of the component feeders have been loaded into their proper corresponding component supply stations. The controller 28 provides a corresponding indication on the monitor 26 to indicate to the operator that the apparatus 10 may be started for assembling the printed circuit boards.

The verification system of the present invention may also b utilized for component replenishment. The apparatus 10 includ s a m ans (not shown) for detecting when the component feeders hav become empty of components

during the component insertion process. When a component feeder is detected as being empty, the apparatus 10 under computer control will stop and the monitor 26 will indicate which component supply station is no longer capable of providing its electrical components. The operator, upon discerning which component supply station requires a new component feeder, removes the spent component feeder from the indicated component supply station and obtains a new component feeder having the required electrical compon nt stored therein. Thereafter, the operator scans the optical bar code on the new component feeder with one of the optical bar code readers 22 or 24 whereupon the controller 28 will cause the visual indicator associated with the component supply station in need of the new component feeder to provide its flashing indication to assist the operator in loading the new component feeder into the proper corresponding component supply station. Thereafter, the controller 28 verifies on the monitor 26 that the new component feeder has been loaded into its proper corresponding supply station. Once the replenishment process is completed, the apparatus 10 may once again be started to continue the insertion of the electrical components into the printed circuit board under assembly.

Referring now to Fig. 2, it is a perspective view of one of the device tables, for example device table 18 and a component feeder, such as component feeder 34 which has been loaded into its proper corresponding component supply station. The device table 18 includes a lower shelf portion 60 and an upper shelf portion 62. The lower shelf portion 60 is spaced from the upper shelf portion 62 such the when the component feeder 34 is loaded into its corresponding component supply station, the bottom surfac 35 of the component feeder 34 is supported by the lower shelf portion 60.

In accordance with this preferred embodiment of the present invention, a visual indicator 64 in the form of a light emitting diode is associated with each of the

component supply stations 30. As previously mentioned, each of the light emitting diodes 64 assist the operator in loading each of the component feeders into its corresponding component supply station.

Also in accordance with the present invention, a passive detecting means 66 is also associated with each of the component supply stations 30. The passive detecting means 66 may each take the form of a Hall effect detector for detecting the presence of a component feeder in its associated component supply station. This permits the controller 28 (Fig. 1) to know which component supply station has received the last loaded component feeder to permit the controller 28 to verify that the component feeder has been loaded into its proper corresponding component supply station.

Referring now to Fig. 3, it is a side view of the component feeder 34 in spaced apart relation to the upper shelf 62 of the device table 18 just prior to the component feeder 34 being received by its corresponding component supply station. The side panel of the component feeder 34 is removed so as to expose the major internal elements of the component feeder 34.

The component feeder 34 includes a supply reel 70 which stores a component supply tape 72, of the type well known in the art, which encapsulates a given one of th electrical components 74. The tape 72 includes a bottom portion 76 which includes a plurality of spaced apart cavities 78 in which the components 74 are stored. The tape 72 further includes a top laminate portion 80 which is peeled from the bottom portion 76 by a peel-back roller 82 to permit the components 74 to be exposed to the pick-up tube 52 one at a time when the component supply station in which the component feeder 34 is received is aligned with the circuit board 12 and the pick-up tube 52. After the top laminate 88 is peeled back from the bottom tape portion 76 by the peel roller 82, it is stored in a take-up reel 83 in a manner well known in the art. Th exposed component

is then picked up from its associated cavity by the pick-up tube 52 and conveyed to th insertion mechanism for insertion into the circuit board 12. The apparatus 10 (Fig. 1), in accordance with a manner known in the art, then cuts the used cavity portion of the tape from the tape 72.

As will be noted in Fig. 3, each of the component supply stations includes a pair of alignment pins 84 adapted to be received by a pair of alignment apertures 86 provided in the component feeder 34. Hence, the pins 84 and apertures 86 form receiving means for receiving a component feeder in its respective corresponding component supply station.

As will be also noted in Fig. 3, the upper shelf 62 includes the light emitting diode 64 and a Hall effect detector 66 associated with the component supply station which is receiving the component feeder 34. The component feeder 34 is provided with a magnet which is aligned with and closely spaced to the Hall effect detector 66 when the pins 84 are received by the apertures 86 and thus when the component feeder 34 is loaded into its corresponding component supply station. This permits the Hall effect detector 66 to detect the presence of the component feeder 34 in its corresponding component supply station.

Referring now to Fig. 4, it is a schematic block diagram of a verification system 90 configured in accordance with this preferred embodiment of the present invention. The system 90 generally includes the controller 28, one of the optical bar code readers 22, the monitor 26, the light emitting diodes 64, and the Hall effect detectors 66. The verification system 90 further includes a component identifier in the form of an optical bar code 92 associated with each component feeders such as component feeder 34, a first multiplexer 94, and a second multiplexer 96.

The first multiplexer 94 couples each of the Hall effect detectors 66 to an input 98 of the controller 28.

To that end, the multiplexer 94 includes a multiple-bit input 100 which is coupled to the Hall eff ct detectors 66 over a multiple-bit bus 102. As illustrated, each conductor of the multiple-bit bus 102 is coupled to a respective given one of the Hall effect detectors 66. Another multiple-bit bus 104 conveys addresses from the controller 28 to a multiple-bit address input 106 of multiplexer 94. This permits the controller 28 to repeatedly address each of the Hall effect detectors 66. The condition of the Hall effect detector being addressed is then conveyed to the input 98 over a conductor 108.

The second multiplexer 96 couples the controller 28 to each of the light emitting diodes 64. To that end, the multiplexer 96 includes a multiple-bit output 110 which is coupled to each of the light-emitting diodes 64 over a multiple-bit bus 112. As illustrated, each conductor of bus 112 is coupled to a respective given one of the light emitting diodes 64. Another multiple-bit bus 114 is coupled to a multiple-bit address input 116 of multiplexer 96. This permits the controller 28 to address any one of the outputs of output 110 for controlling any one of the light emitting diodes 64. The control signal for controlling the addressed light emitting diode is conveyed over a conductor 118 from the controller 28 to an input 120 of multiplexer 96.

The operation of the verification system 90 and the process of loading a plurality of component feeders into corresponding component supply stations may be best understood by making reference to the flow diagram 130 illustrated in Fig. 5. The process begins in step 132 wherein the program associated with the printed circuit board to be assembled is loaded into the apparatus 10 and the controller 28. As previously mentioned, the program associated with the printed circuit board to be assembled may be selected on the keyboard 54 illustrated in Fig. 1.

Once the program has been loaded into the controller 28, the controller 28 in step 134 addresses and turns on

through multiplexer 96 all of the light emitting diodes 66 which are associated with component supply stations which are to receive a component feeder. In this stage of the process, all of the light emitting diodes 64 which are turned on are preferably turned on to provide a first indication, such as a continuous indication, to identify for the operator all of the component supply stations which are to receive a component feeder.

After step 134 is completed, the operator then will scan the optical bar code of a first component feeder required by the selected program with the optical bar code reader 22 in step 136. After the optical bar code is scanned, the controller 28 determines if the optical bar code read by the optical bar code reader 22 is in the correct format in accordance with step 138. If it is not in the correct format, the process returns to step 136 for the rescanning of the optical bar code. If the optical bar code is in the proper format, the controller 28, in step 140, then correlates the component identifier of the bar code with the corresponding component supply station and causes the light emitting diode of the associated component supply station to flash. In performing step 140, the controller 28 addresses the light emitting diode associated with the corresponding component supply station through multiplexer 96 and concurrently therewith supplies the control signal over conductor 118 to cause the light emitting diode to flash. The flashing light emitting diod identifies for the operator the component supply station which is to receive the component feeder which has just been scanned by the optical bar code reader.

The operator then, in step 142, loads the component feeder into its corresponding component supply station. Hence, the verification system of the present invention is interactive with the operator to assist the operator in loading each compon nt feeder into its corresponding component supply station.

After the component feeder has b en loaded, the controller 28 then, in step 144, determines if the component feeder has been loaded into its corresponding component supply station. In performing step 144, the Hall effect detector associated with the component supply station receiving the component feeder detects the presence of the component feeder. The controller 28, through the address used to address the Hall effect detector detecting the presence of the component feeder, determines if the component feeder has been placed into the proper corresponding component supply station. If the component feeder is not in the correct component supply station, the controller 28 then in step 146 indicates on the monitor 26 that there has been an error in the loading of the component feeder and returns to step 136 to require the operator to once again scan the component feeder optical bar code and to repeat the loading process of the component feeder. If the controller 28 determines that the component feeder has been loaded into the proper corresponding component supply station, the controller 28 then advances to step 147 to determine if all of the component feeders required by the program for assembling the printed circuit board have been loaded. If additional feeders must be loaded, the process then returns to step 136 whereupon the operator selects the next component feeder and scans its optical bar code for completing the loading process for this next component feeder. When all of the component feeders have been loaded as determined in step 147, the process moves to step 148.

In step 148, the controller 28 stores all of the feeder data in its internal memory. Such feeder data is preferably the component identifiers and the corresponding component supply stations in which the component feeders have been loaded. This step provides the controller 28 with the data required for handling component replenishment as previously described. Also, this data is valuable f r changeover when a different printed circuit board is to b

assembled. This next printed circuit board may require some identical combinations of component feeders and corresponding component supply stations as the immediately preceding printed circuit board. If this is the case, when the new program associated with the next printed circuit board is loaded, the controller 28 will identify on the monitor 26 which component supply stations will require a different component feeder. This provides assistance to the operator in removing those component feeders from th device tables which will not be utilized in assembling the next printed circuit board. When those component feeders which will not be utilized are removed from the device table, the controller 28 will cause the light emitting diodes associated with those component supply stations which are to be utilized in the assembly of the next printed circuit board to be continuously illuminated.

After step 148 is completed, the process then proceeds to step 150 wherein the controller 28 displays on th monitor 26 that all of the component feeders have been loaded in their proper corresponding component supply stations and that the apparatus 10 may be started to begin the assembly of the printed circuit boards. Once the apparatus 10 is started, the process of loading all of the required component feeders into their corresponding component supply stations is completed.

Referring now to Fig. 6, it illustrates the operation of the verification system 90 when the operation of the apparatus 10 has been disturbed due to one of the component feeders being empty of its component or due to one of the component feeders being removed during the operation of the apparatus. As can be appreciated from the foregoing, each of the Hall effect detectors 66 continuously senses the presence of a component feeder in its associated component supply station during the operation of the apparatus 10. If a component feeder is removed from its associated supply station, the process of flow diagram 160 begins in step 162 wherein the controller 28 d termines from the condition of

the Hall effect detectors 66 if a component feeder has b en removed from an associat d supply station. Such removal may be due to inadvertence or due to the apparatus 10 detecting an empty component feeder. As indicated, the controller 28 continuously senses for this condition.

If it is determined in step 162 that a component feeder has been removed, the controller 28 in step 164 stops the apparatus 10 if it is not already stopped. Th controller also, from the Hall effect detector detecting the absence of a component feeder, addresses and turns on through multiplexer 96 the light emitting diode 64 associated with the component supply station which is in need of a component feeder. In this stage of the process, the light emitting diode 64 which is turned on is preferably turned on to provide the first indication, such as the continuous indication, to identify for the operator, the component supply station which is to receive the needed component feeder.

After step 164 is completed, the operator then will scan the optical bar code of the required component feeder. After the optical bar code is scanned, the controller 28 determines if the optical bar code read by the optical bar code reader 22 is in the correct format in accordance with step 168. If it is not in the correct format, the process returns to step 166 for the rescanning of the optical bar code. If the optical bar code is in the proper format, the controller 28, in step 170, then correlates the component identifier of the bar code with the corresponding component supply station and causes the light emitting diode of the associated component supply station to flash. In performing step 170, the controller 28, as previously described, addresses the light emitting diode associated with the corresponding component supply station through multiplexer 96 and concurrently therewith supplies the control signal over conductor 118 to cause the light emitting diode to flash. The flashing light emitting diode advises the operator that the component feeder just scanned

is the proper one for the component supply station in need of a component feeder.

The operator then, in step 172, loads the component feeder into its corresponding component supply station.

After the component feeder has been loaded, the controller 28 then, in step 174, determines if the component feeder has been loaded into the correct component supply station. In performing step 174, the Hall effect detector associated with the component supply station receiving the component feeder detects the presence of th component feeder. The controller 28, through the address used to address the Hall effect detector detecting the presence of the component feeder, determines if the component feeder has been placed into the proper corresponding component supply station. If the component feeder is not in the correct component supply station, the controller 28 then in step 176 indicates on the monitor 26 that there has been an error in the loading of the component feeder and returns to step 166 to require th operator to once again scan the component feeder optical bar code. If the controller 28 determines that the component feeder has been loaded into the proper corresponding component supply station, the controller 28 then advances to step 178 to store or update its feeder data in its internal memory. This updates the feeder data with the component identifier of the replaced component feeder and its corresponding component supply station.

After step 178 is completed, the process then proceeds to step 180 wherein the controller 28 displays on the monitor 26 that the required component feeder has been replaced into its proper corresponding component supply station and that the apparatus 10 may be started to resume the assembly of the printed circuit board. The foregoing process is repeated as needed any time a Hall effect detector detects the absence of a required component feeder from its corresponding component supply station.

While a particular embodiment of th present invention has been shown and described, modifications may be made, and it is therefore intended in the appended claims all such changes and modifications which fall within the true spirit and scope of the invention.

1. An apparatus for automatically assembling a plurality of components into a finished product, said apparatus sequentially aligning a product under assembly with a plurality of work stations, each said work station being dedicated to provide a given component for assembly in said product under assembly, said apparatus comprising:

a plurality of component storage means, each said component storage means for storing a plurality of a given one of said components and including a component identifier identifying the given one of said components stored therein;

receiving means at each one of said work stations for receiving one of said component storage means, each said receiving means including visual indicator means for providing a visual indication;

reading means for reading each of said component identifiers one at a time; and

correlating means for correlating each of said component identifiers with a corresponding one of said receiving means, said correlating means being coupled to said reading means and to each of said visual indicator means and being responsive to said component identifiers for causing, for each component identifier read by said reading means, a corresponding one of said visual indicator means to provide said visual indication to assist an operator in loading each said component storage means into its corresponding receiving means.

2. An apparatus as defined in claim 1 wherein said visual indicator means comprise light emitting diodes.

3. An apparatus as defined in claim 1 wherein each said indicator means provides, responsive to said correlating means, a first visual indication when its

receiving means is to receive one of said component storage means.

4. An apparatus as defined in claim 3 wherein each said indicator means is responsive to said correlating means for providing a second visual indication when a component identifier corresponding to its receiving means is read by said reading means.

5. An apparatus as defined in claim 4 wherein said first visual indication is a continuous visual indication.

6. An apparatus as defined in claim 5 wherein said second visual indication is a discontinuous visual indication.

7. An apparatus as defined in claim 1 wherein each of said receiving means includes detecting means for detecting the presence of one of said component storage means in its receiving means, and wherein said correlating means includes verification means for verifying, after each said component storage means is loaded into one of said receiving means, whether the loaded component storage means has been received by its corresponding receiving means.

8. An apparatus as defined in claim 7 wherein each said detecting means includes a Hall effect detector.

9. An apparatus as defined in claim 8 wherein each said component storage means includes a magnet for actuating said Hall effect detectors.

10. An apparatus as defined in claim 1 wherein each said component identifier comprises an optical bar code and wherein said reading means is an optical bar code reader.

11. An apparatus for automatically assembling a plurality of components into a finished product, said

apparatus sequentially aligning a product under assembly with a plurality of work stations, each said work station being dedicated to provide a given component for assembly in said product under assembly, said apparatus comprising:

a plurality of component storage means, each said component storage means for storing a plurality of a given one of said components;

receiving means at each one of said work stations for receiving one of said component storage means;

control means for establishing a correspondence between each said component storage means and corresponding ones of said receiving means;

detecting means associated with each said receiving means for detecting the presence of one of said component storage means in its associated receiving means; and

correlating means responsive to said control means and said detecting means for verifying, after each said component storage means is loaded into one of said receiving means, whether the loaded component storage means has been received by its corresponding receiving means.

12. An apparatus as defined in claim 11 wherein each said detecting means includes a Hall effect detector.

13. An apparatus as defined in claim 12 wherein each said component storage means includes a magnet for actuating said Hall effect detectors.

14. An apparatus as defined in claim 11 wherein each said detecting means continuously detects for the presence of one of said component storage means in its associated receiving means.

15. An apparatus as defined in claim 14 wherein said correlating means interrupts operation of said apparatus responsive to one of said detecting means detecting the absence of one of said component storage means from its associated receiving means.

16. An apparatus as defined in claim 15 wherein each said detecting means includes a Hall effect detector.

17. An apparatus as defined in claim 16 wherein each said component storage means includes a magnet for actuating said Hall effect detectors.

18. An apparatus as defined in claim 11 wherein said control means includes reading means for reading each of said component storage means one at a time prior to loading each of said component storage means into one of said work station receiving means.

19. An apparatus as defined in claim 18 wherein each of said receiving means includes visual indicator means for providing a visual indication, and wherein said correlating means also correlating correlating each of said component storage means with a corresponding one of said work station receiving means, said correlating means being coupled to said reading means and to each of said visual indicator means and being responsive for causing, for each component storage means read by said reading means, a corresponding one of said visual indicator means to provide said visual indication to assist an operator in loading each said component storage means into its corresponding work station receiving means.

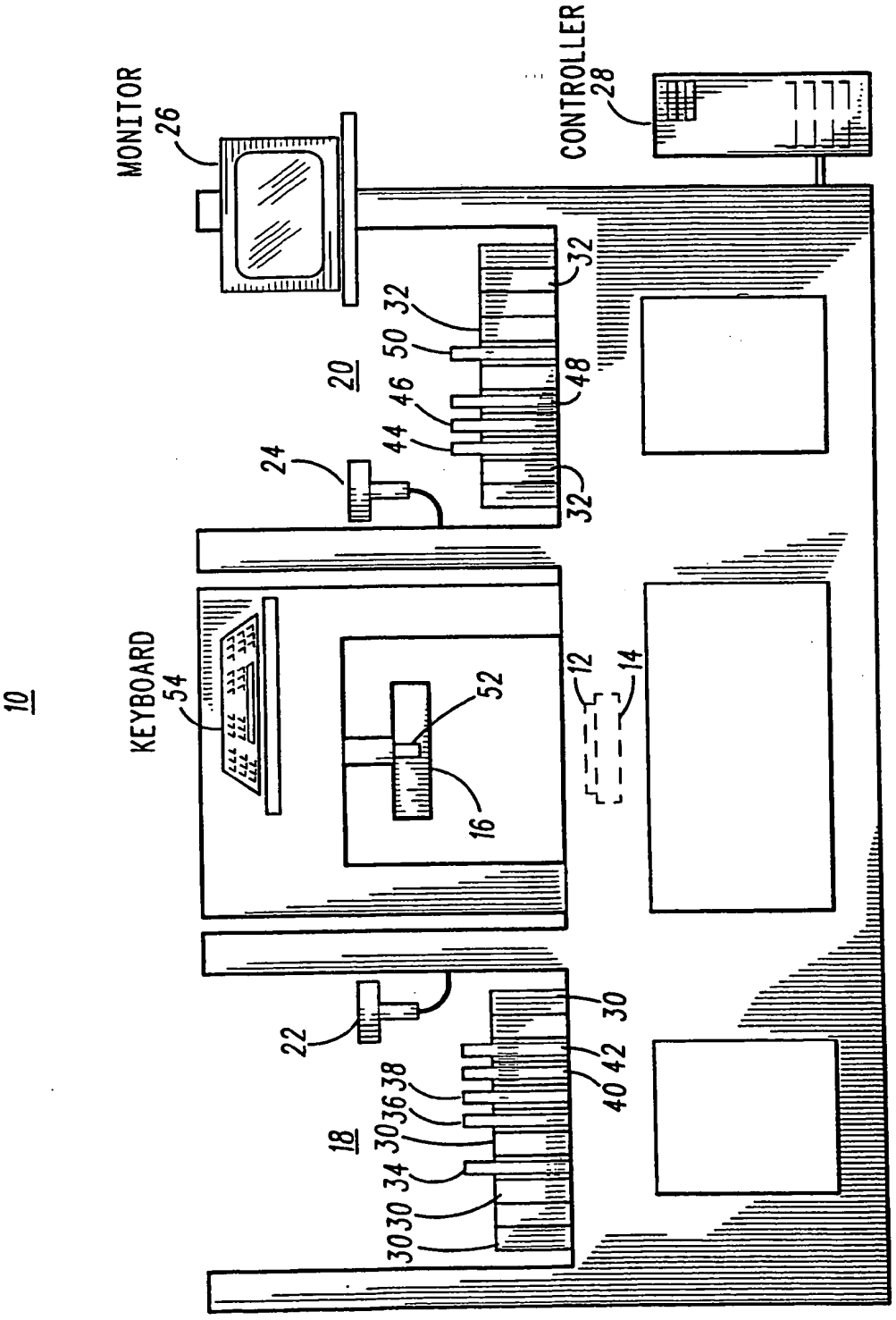
MONITOR
26
CONTROLLER
28
10
KEYBOARD
54
20
18
24
22
12
14
16
52
32
50
48
46
44
30
42
40
38
36
34

FIG. 1

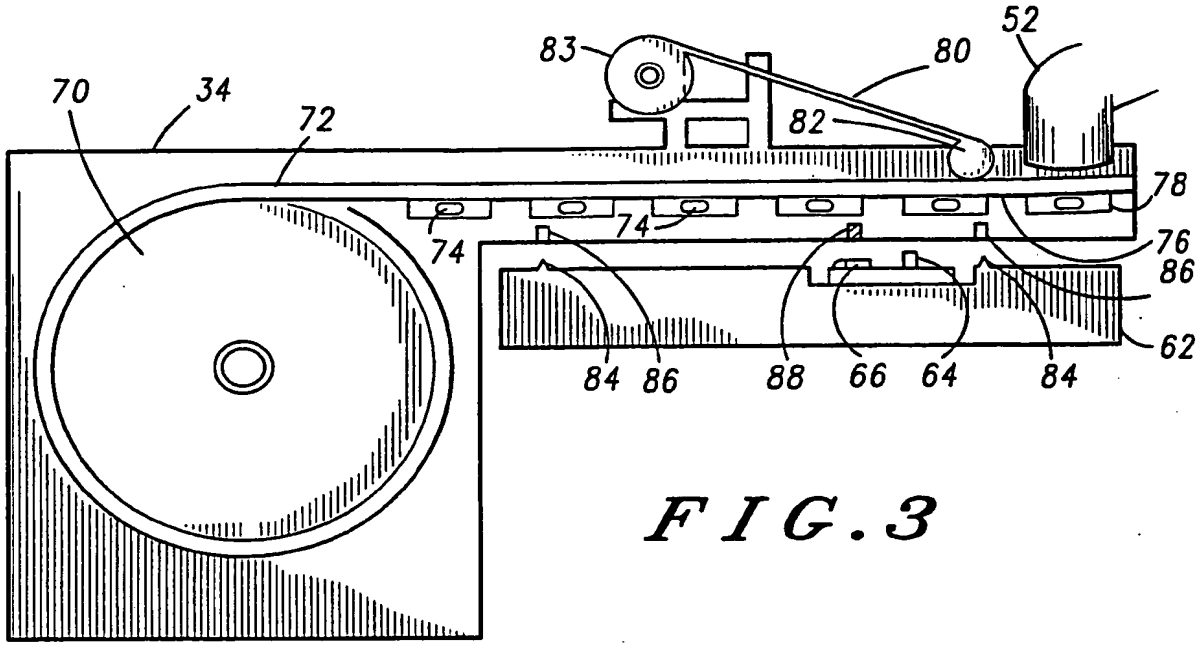

FIG. 3

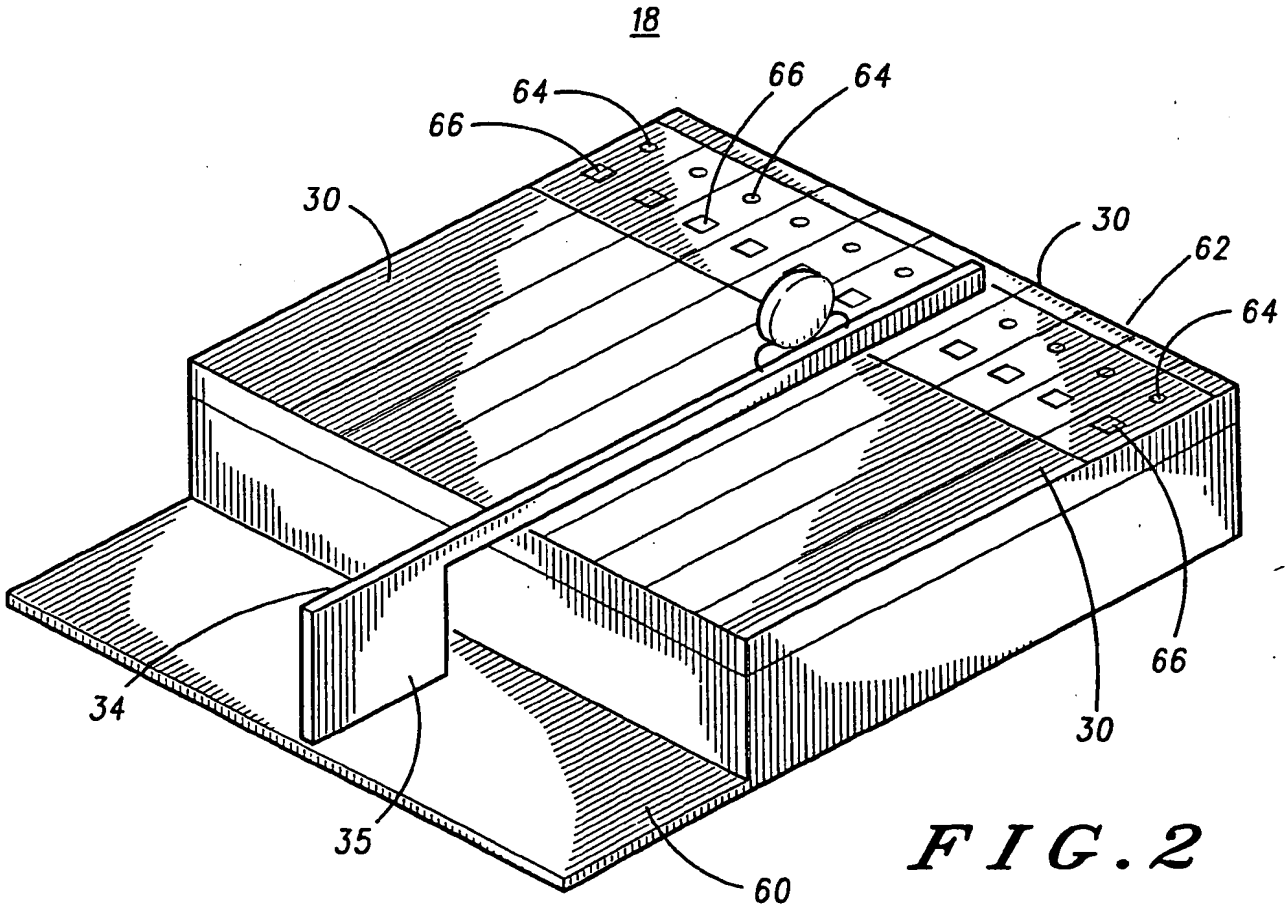

FIG. 2

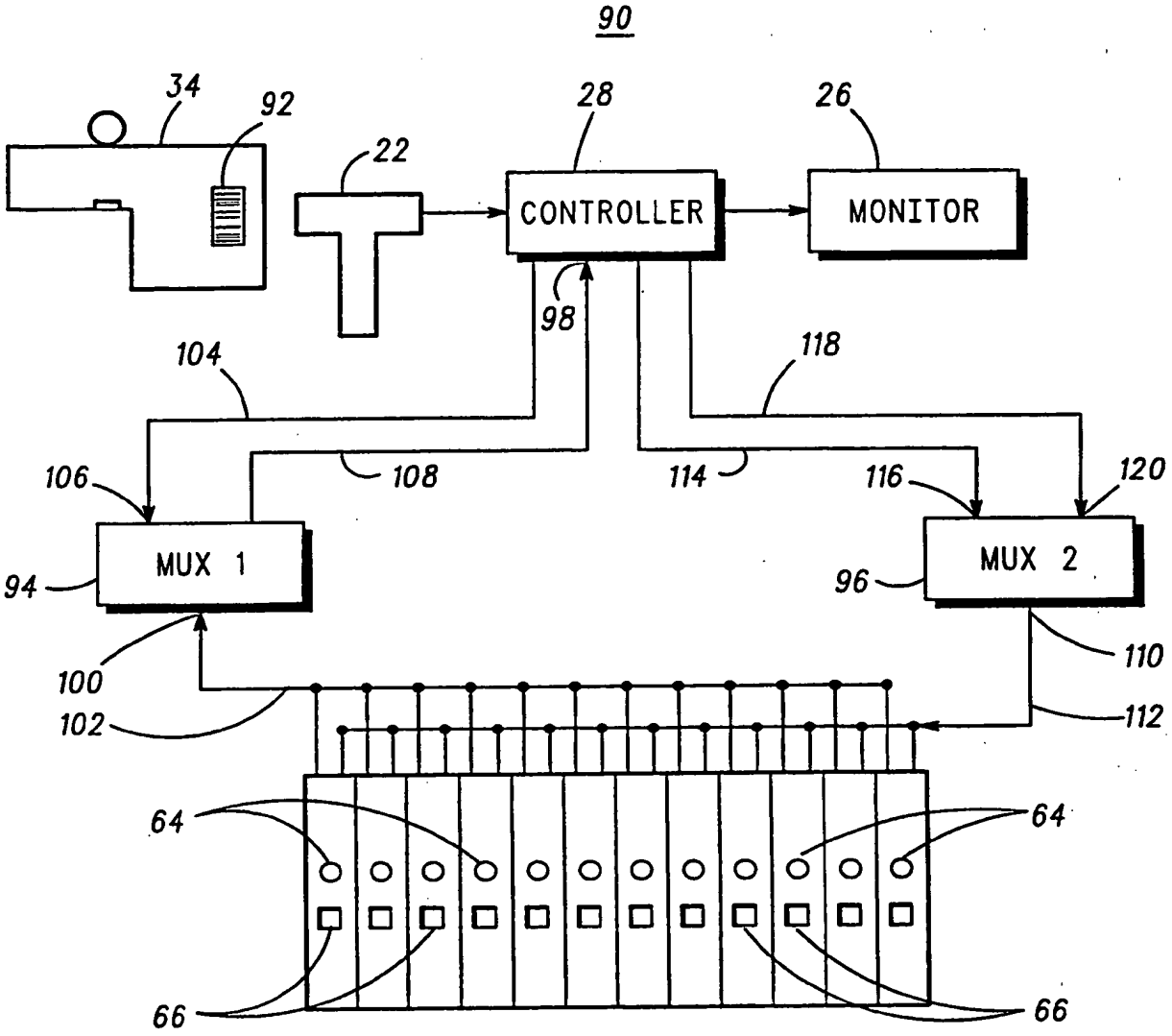
90
34
92
22
28
26
CONTROLLER
MONITOR
98
104
118
106
108
114
116
120
MUX 1
MUX 2
94
96
100
110
102
112
64
64
66
66

FIG. 4

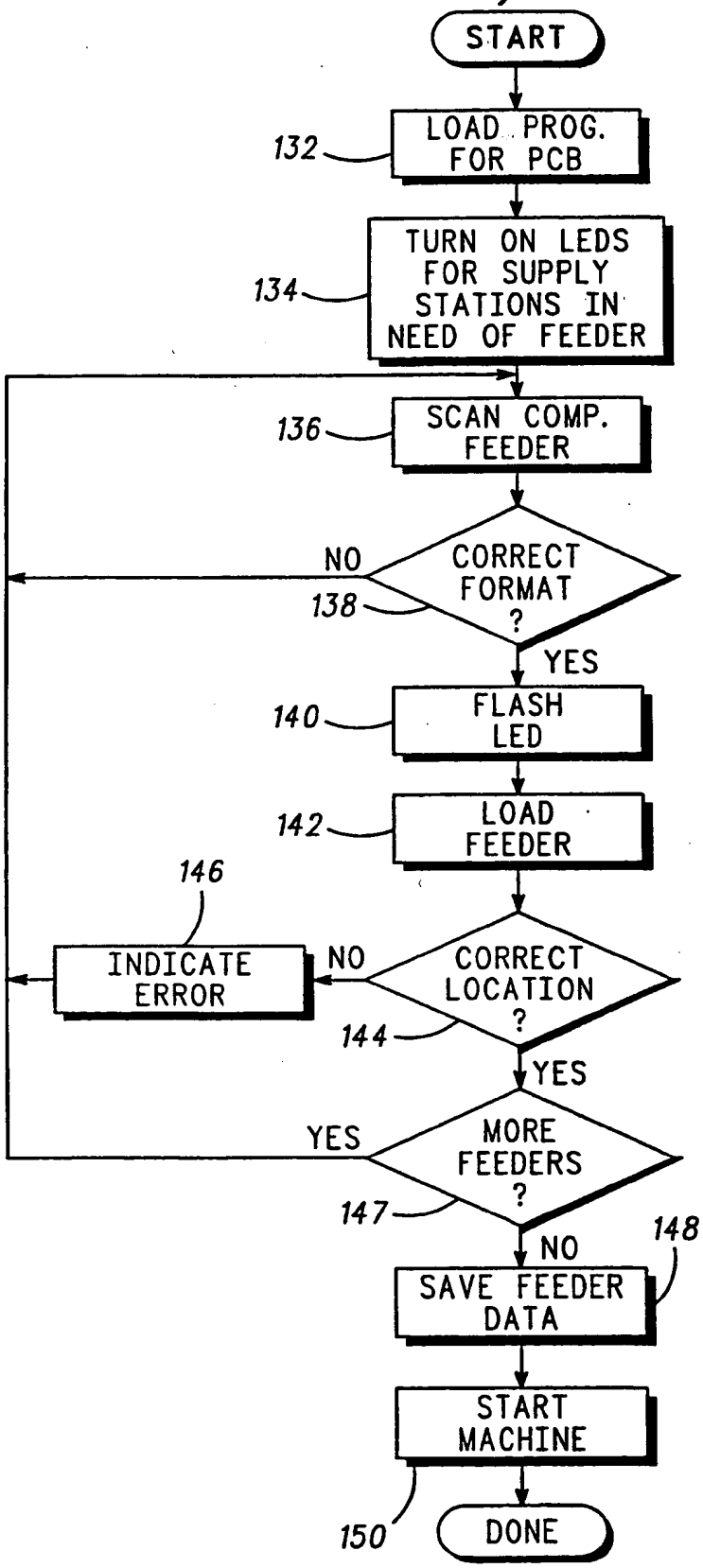

FIG. 5

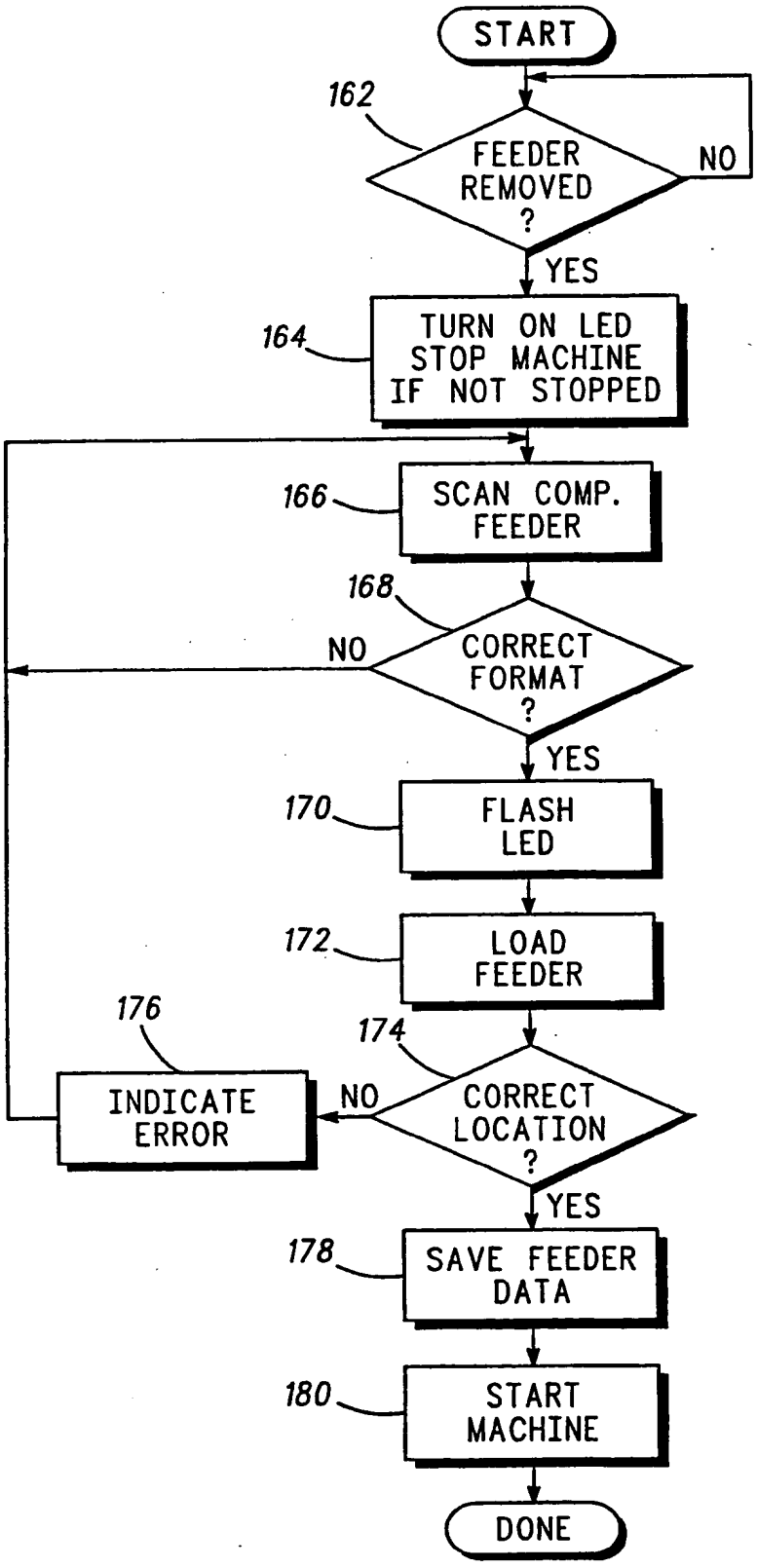
START
162
FEEDER REMOVED ?
NO
YES
164
TURN ON LED STOP MACHINE IF NOT STOPPED
166
SCAN COMP. FEEDER
168
CORRECT FORMAT ?
NO
YES
170
FLASH LED
172
LOAD FEEDER
174
CORRECT LOCATION ?
NO
176
INDICATE ERROR
YES
178
SAVE FEEDER DATA
180
START MACHINE
DONE
160

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/05421

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :G06F 15/46
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	US,A,5283943 (AGUAYO ET AL) 8 FEBRUARY 1994, SEE FIGURE 1	1-19
A	US,A, 4889229 (YAMAMOTO ET AL) 26 DECEMBER 1989, SEE FIGURE 1	1-19
A	US,A, 4837904 (ABE ET AL.) 13 JUNE 1989, SEE FIGURE 1	1-19
A	US,A,4667403 (EDINGER ET AL) 26 MAY 1987, SEE FIGURE 1	1-19
A	US,A,4651863 (REUTER ET AL) 24 MARCH 1987, SEE FIGURE 8	1-19
A	US,A,4598459 (KLINK ET AL) 8 JULY 1986, SEE FIGURE 1	1-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 11 JULY 1994	Date of mailing of the international search report 18 OCT 1994
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer JAMES TRAMMELL Telephone No. 305-9768

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/05421

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

364/468

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

364/468,478,479; 29/701,706,720,564.8,407,703,840,342,740; 198/339.1